Sensitivity of Freshwater Mollusks to Hydrilla-targeting Herbicides

Jennifer M. Archambault and W. Gregory Cope
NC State University
Department of Applied Ecology

Acknowledgments

Mollusk Collection/Propagation
Chris Barnhart, Missouri State U.
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SePRO
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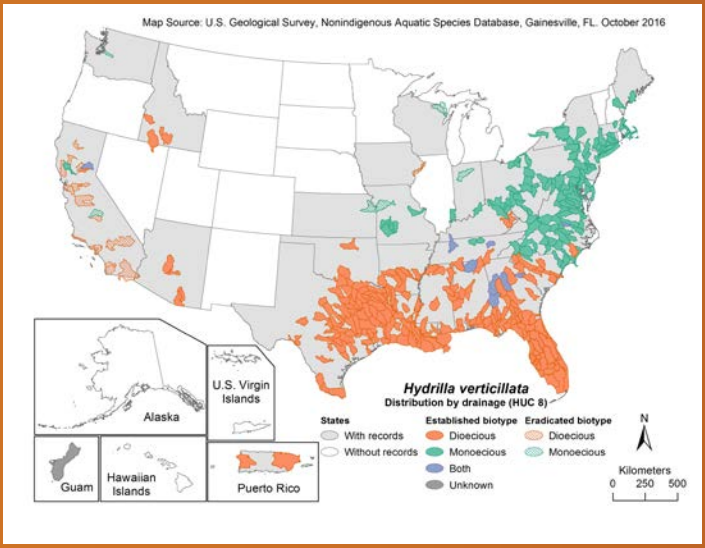
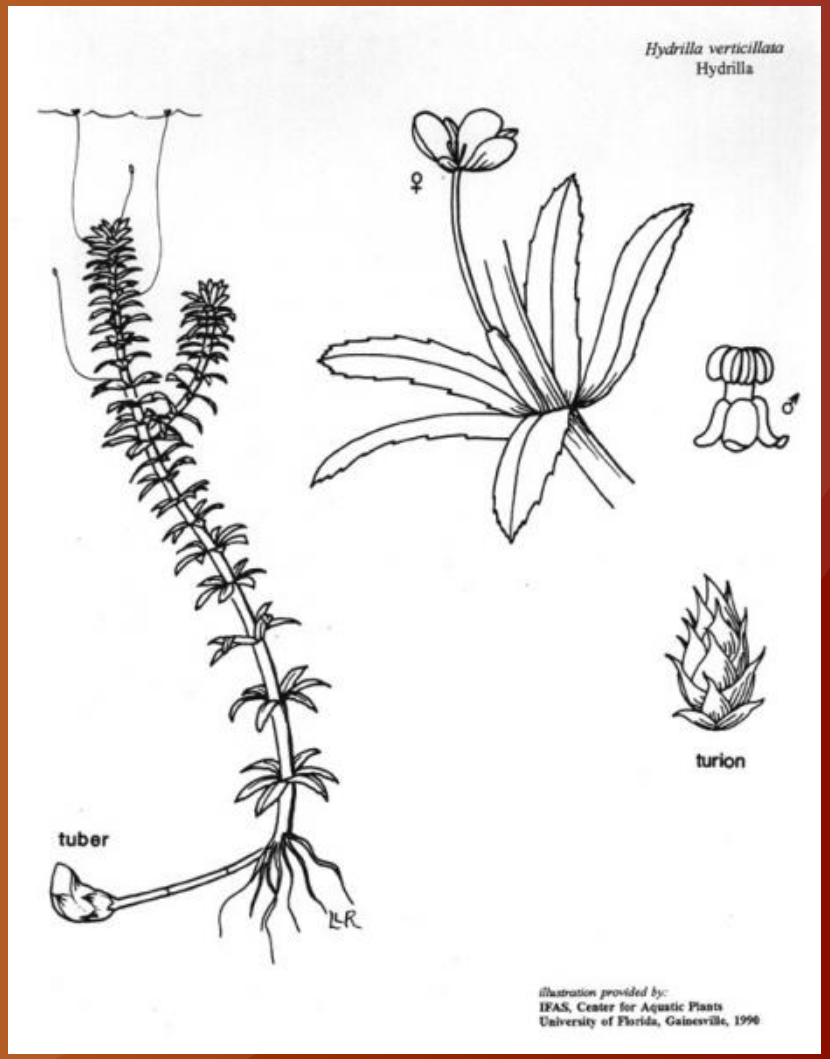
Hydrilla verticillata

- Hydrilla, water-thyme
- Monoecious biotype
  - Spreading by 1970s
  - Tubers, turions, fragments
- Expanding in range
  - Boats, angler equipment





Hydrilla verticillata

- **Federal Noxious Weed in US**
  - **Monocultures**
  - **Alters water quality**
  - **Neurotoxic bacteria & AVM**

Hydrilla verticillata

- **Federal Noxious Weed in US**
  - **Monocultures**
  - **Alters water quality**
  - **Neurotoxic bacteria & AVM**
- **Control Strategies:**
  - **Mechanical removal**
  - **Grass carp**
  - **<u>Herbicides</u>**
    - **Sonar (fluridone)**
    - **Aquathol (endothall)**

Herbicide Mode of Action

- **Sonar (fluridone)**
  - **Chlorophyll / carotenoid pigment inhibitor**
    - **Prohibits plants from making food**
- **Aquathol (endothall)**
  - **Protein phosphatase inhibitor (interferes with respiration)**

Freshwater Mollusks

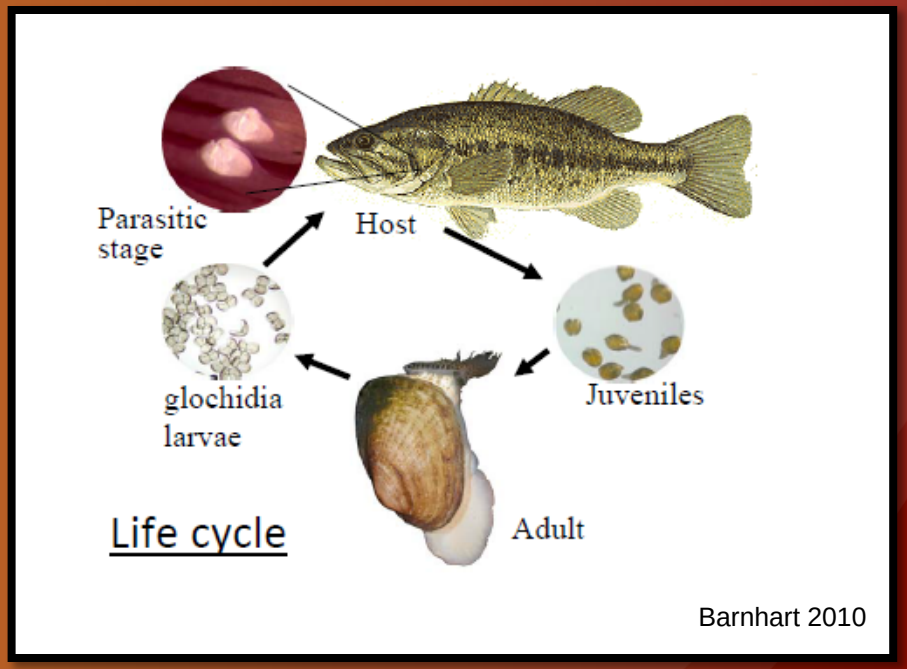
- Extremely imperiled taxa
- Poorly studied
  - Knowledge far behind fishes, mammals, birds…
  - Still need basic science
- Sensitive to contaminants

FWGNA

MC Barnhart

Unionid Mussels

- Found in streams, rivers, lakes, and ponds
- 673 species in Unionidae ~ half in N. America
- > 71% of species imperiled
- Water purifiers
- Unique life history – obligate fish parasite



Barnhart 2010

Gastropods (Snails)

- Found in streams, rivers, lakes, and ponds
- 703 species in US and Canada
- > 74% of species imperiled
- Highly susceptible to habitat loss and degradation


FWGNA

Lake Waccamaw

- 9,000 acre Carolina Bay lake
- Several endemic species
  - 3 fishes – W. silverside, W. killifish, W. darter
  - 2 mussels – W. fatmucket and W. spike
  - 2 snails – W. amnicola and W. siltsnail

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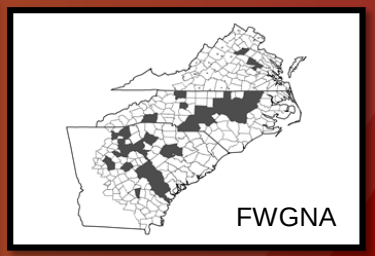
- Hydrilla recently introduced near boat ramp
  - ~ 600 acres infested

Eno River

- NC Piedmont stream, rocky, cobble substrates
- Panhandle pebblesnail present
- Imperiled (NCWAP species; G2)
- Rocky riffles with good flow
- Solid substrate
- Plentiful riffleweed (snail habitat)
- Hydrilla present



Research Needs & Objectives

Few data on invertebrates

No data for freshwater mollusks

Determine sensitivity of native mollusks to aquatic herbicide formulations

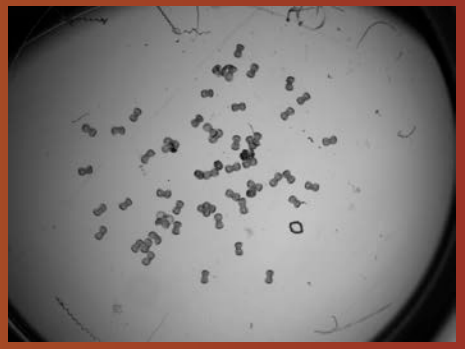
Sonar – Precision Release (PR) and Genesis (i.e., fluridone)

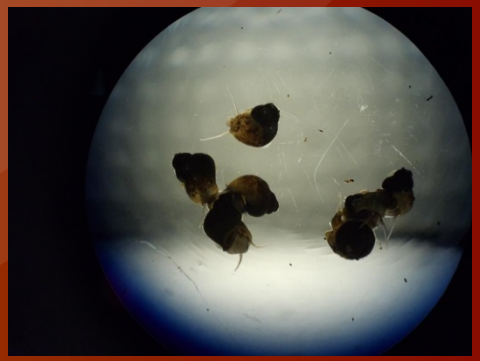
Aquathol – K (i.e., endothall)

Consider results in context of proposed treatment of *Hydrilla*

Acute Toxicity Experiments

- **Fatmucket (*Lampsilis siliquoidea*)**
  - **glochidia and juveniles**
- **Panhandle Pebblesnail (*Somatogyrus virginicus*)**
  - **juveniles and adults**





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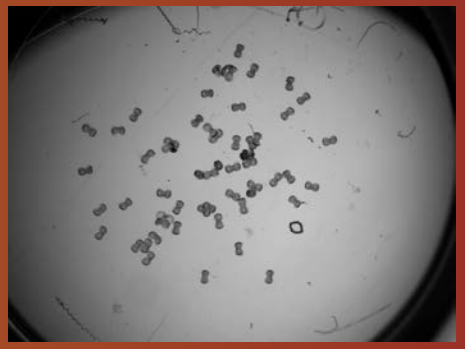
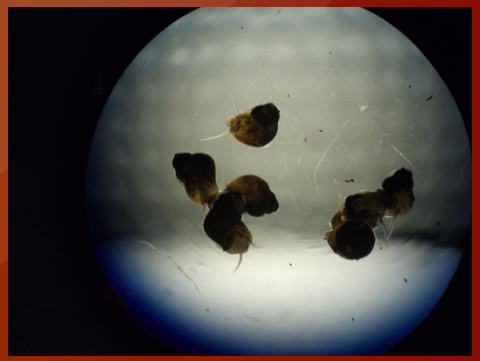
- **Follows ASTM (2006) Standard Guideline for Conducting Toxicity Tests with Mussels**
  - **24 h – glochidia, 96 h – juveniles and snails**





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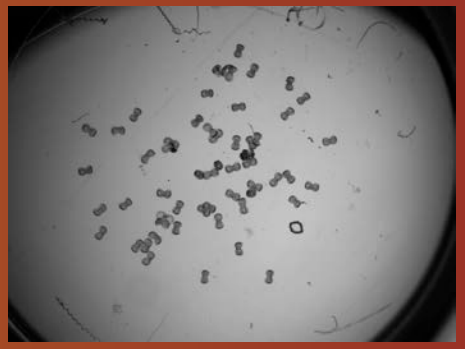
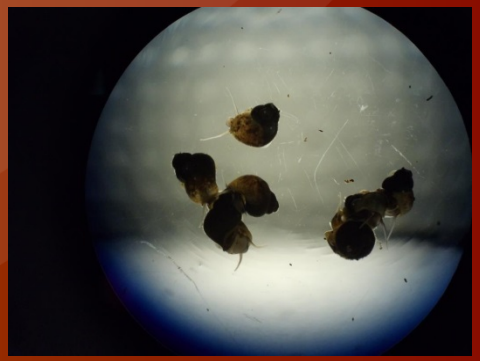
  - juveniles and adults
- Follows ASTM (2006) Standard Guideline for Conducting Toxicity Tests with Mussels
  - 24 h – glochidia, 96 h – juveniles and snails
- **Endpoint – survival**
  - **Glochidia = shell closure response to NaCl**
  - **Snails and juvenile mussels = movement in 5 min**
  - **Median Lethal Concentration (LC50)**





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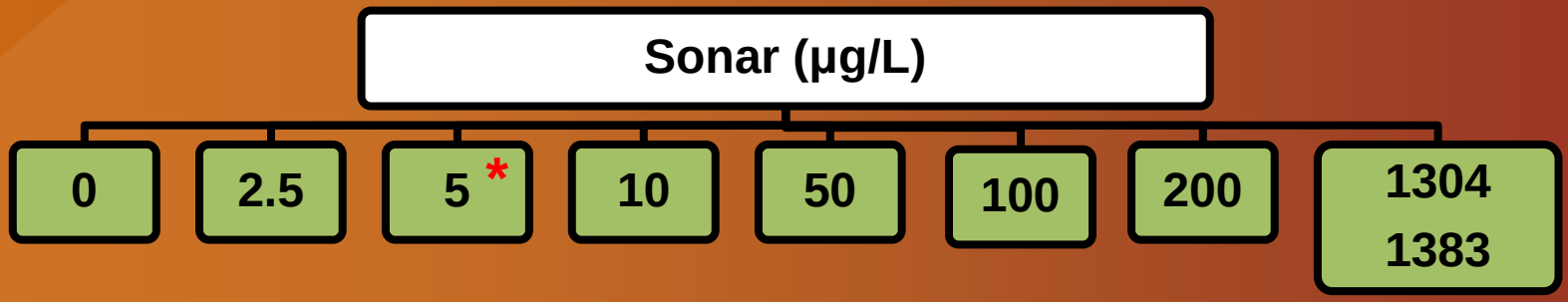
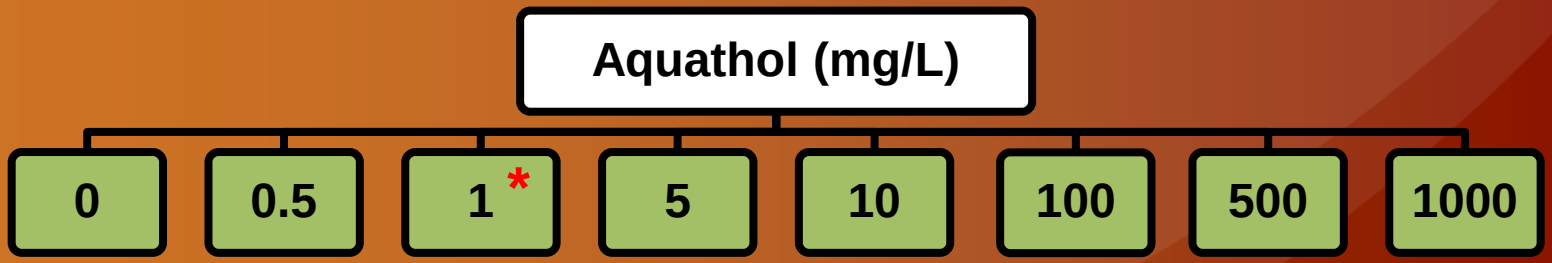


Experiment with adult snails achieved maximum exposure concn. of 564 µg/L.



*** Target application concn.**

3 replicates/ treatment

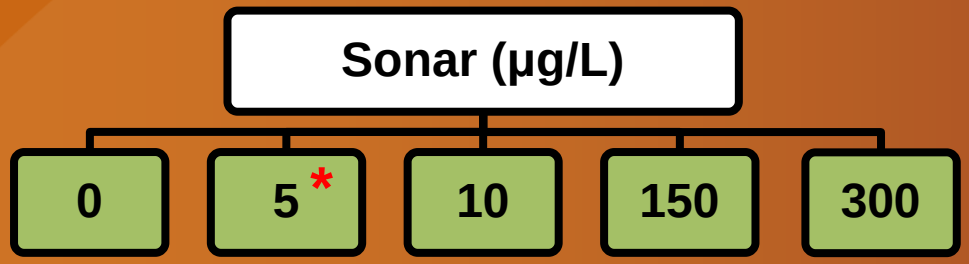
28-d Chronic Experiment

- Waccamaw fatmucket (*L. fullerkati*)

- Static test, aerated, 500 mL, renewed at 72 h

- Endpoints
  - Survival – 7, 14, 21, 28 d
  - Siphoning – # siphoning/exposed
  - Foot protrusion – # extended/exposed

28-d Chronic Experiment

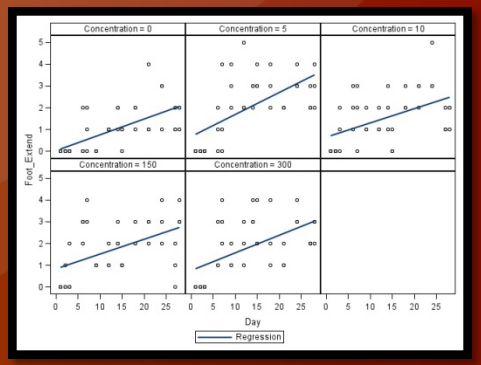


* Target application concn.

Statistical Analysis

- **Viability / Survival:**
  - LC50, Spearman-Karber method (CETIS)

- **Siphoning, Foot Protrusion, Snail Egg Hatching**
  - Repeated measures ANOVA (PROC MIXED, SAS v. 9.3)
  - Dunnett's post-hoc test

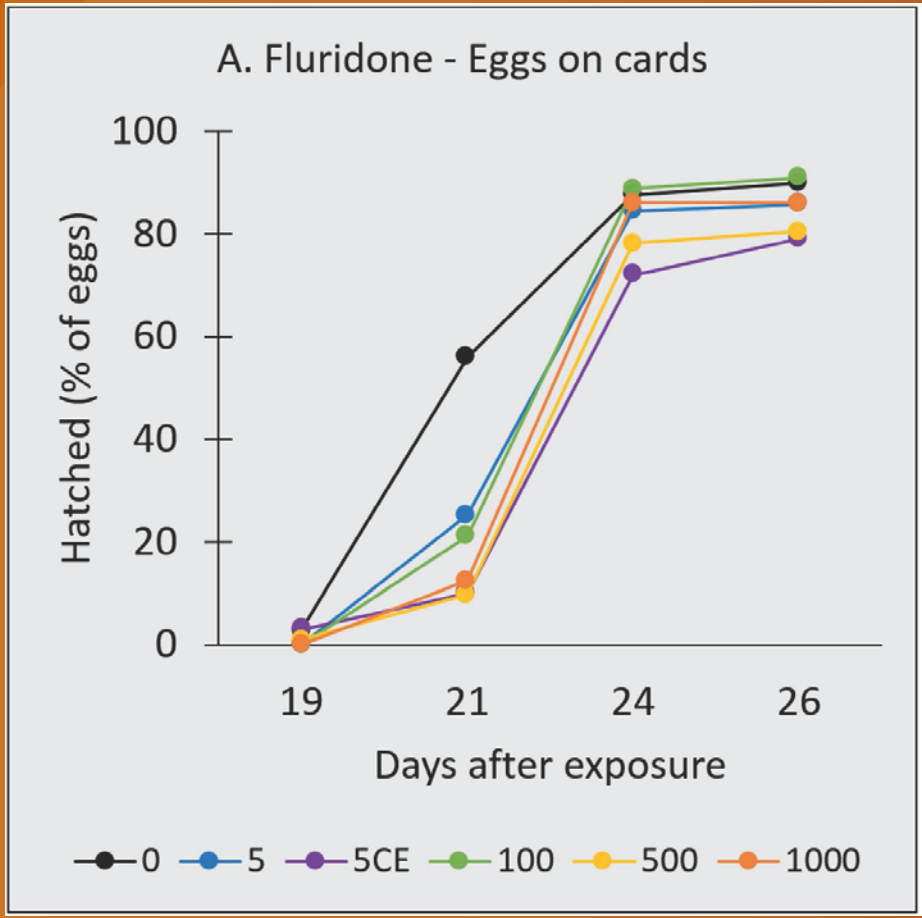


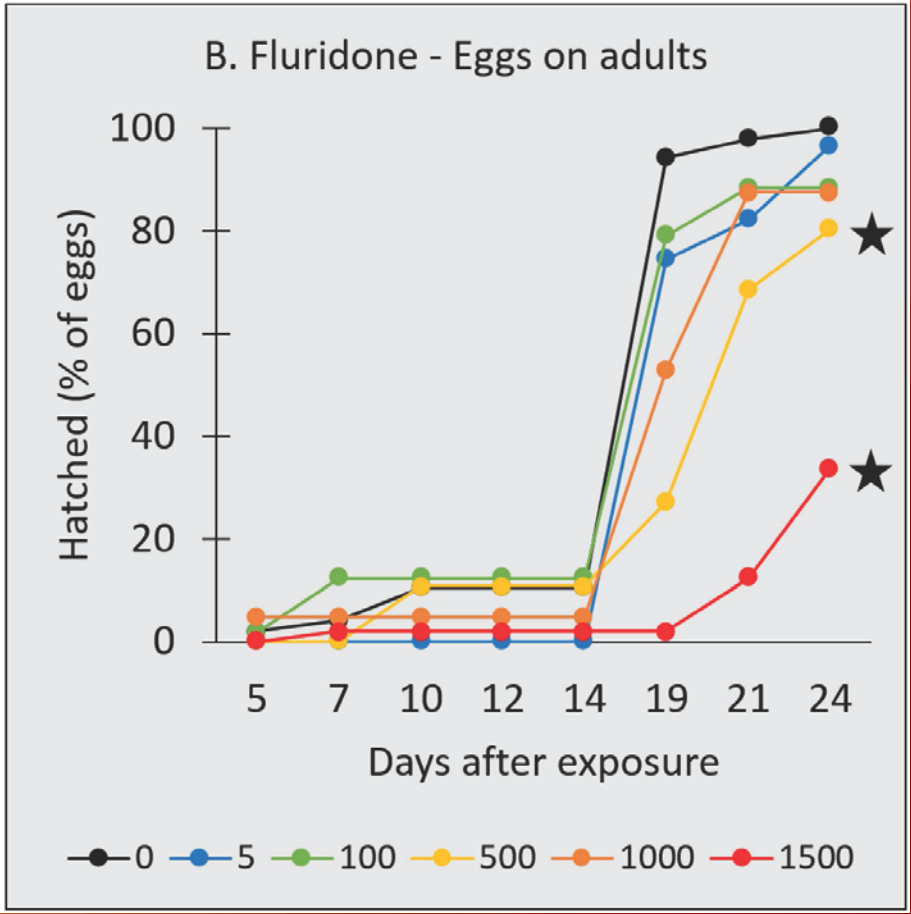
Acute and Chronic LC50s

Species	Life stage	Time point	Sonar (µg/L)	Aquathol (mg/L)
Fatmucket	glochidia	24 h	**865** (729 – 1026)	**31.2** (30.3 – 32.2)
	juvenile	96 h	**511** (309 – 843)	**34.4** (29.3 – 40.5)
P. pebblesnail	juvenile	96 h	**500** (452 – 553)	**---**
		48-h post	**409** (329 – 509)	**---**
	adult	96 h	**> 564 (no mortality)**	**224** (157 – 318)
Wac. fatmucket	adult	28 d	**ND – no mortality**	**---**

Snail Hatching Success

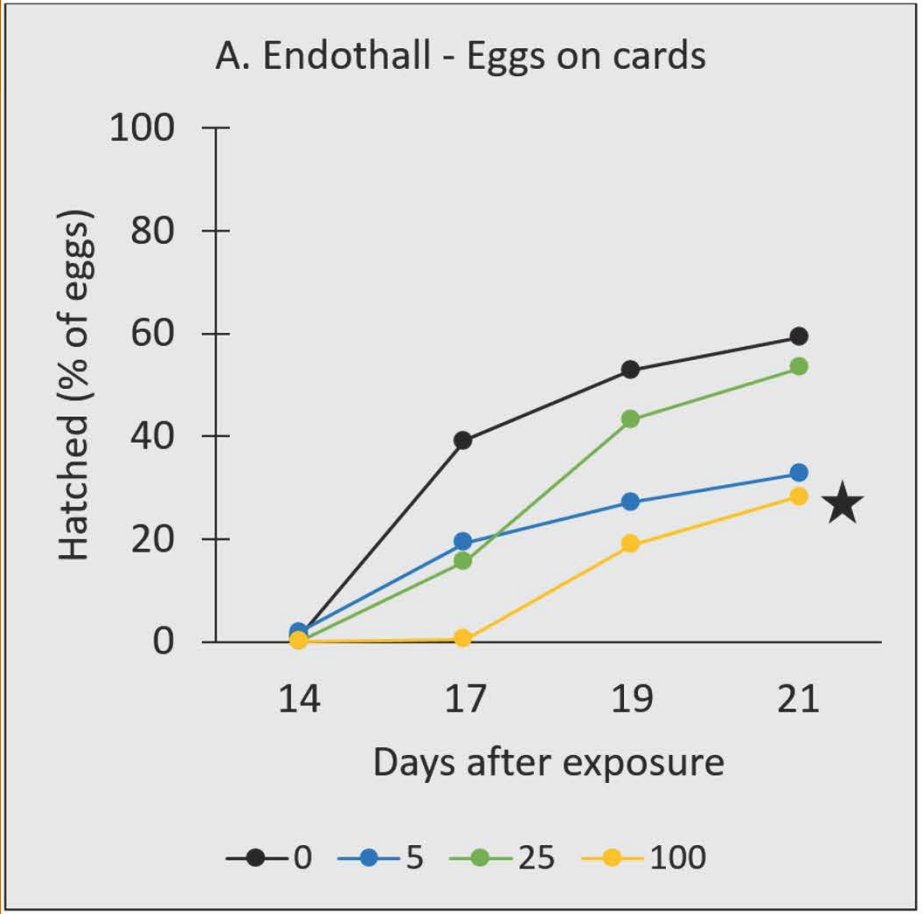
Fluridone

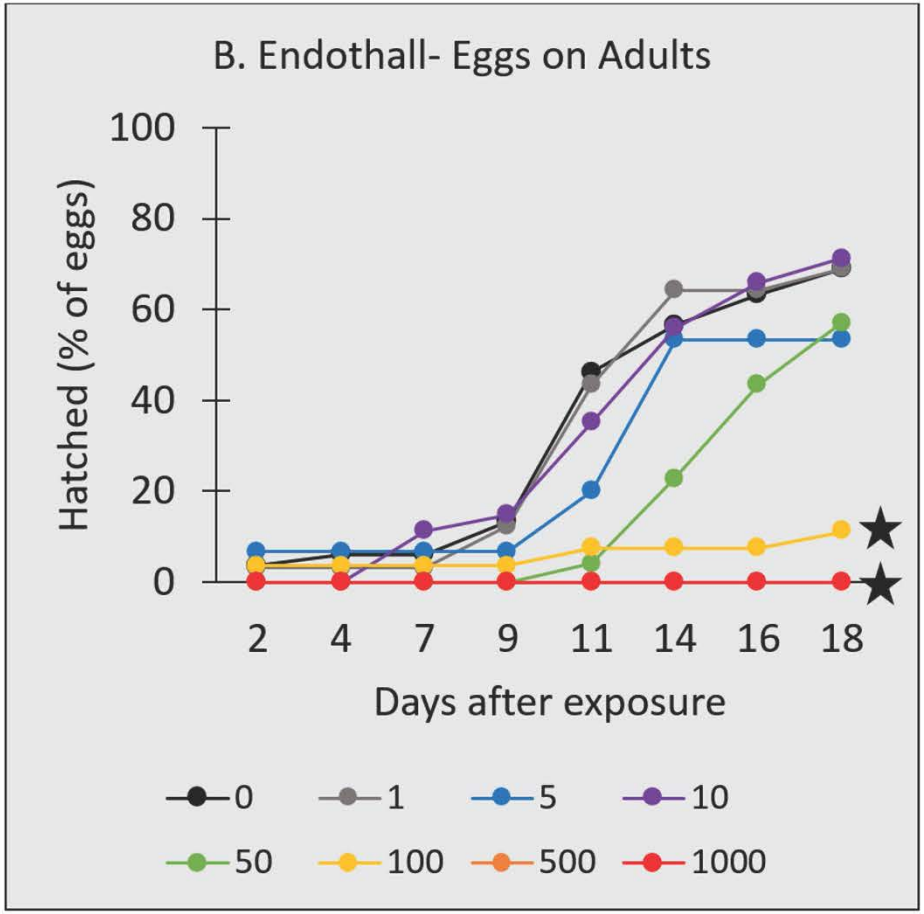




Snail Hatching Success

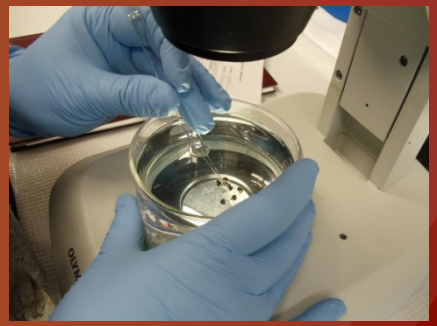
Endothall





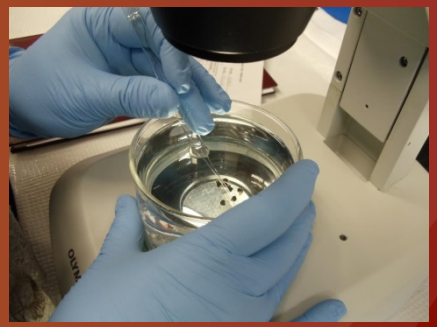
Fluridone Comparative Toxicity - Acute

- Sonar – PR & Genesis typically applied at 5 ppb
  - Max application rate = 150 ppb



Fluridone Comparative Toxicity - Acute

- Sonar – PR & Genesis typically applied at 5 ppb
  - Max application rate = 150 ppb
- LC50s for freshwater species
  - Fish (96 h): 1.8 – 13 ppm
  - Daphnia (48 h): 3.6 – 3.9 ppm
  - Snail (96 – 48 h post): 409 – >564 ppb
  - Mussels (24 – 96 h): 511 – 865 ppb



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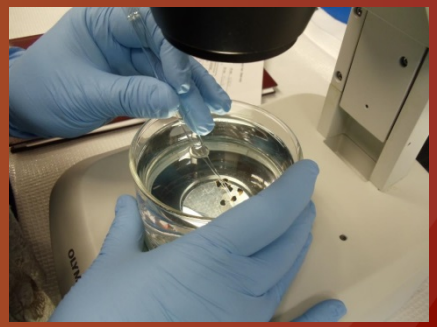
  - Snail (96 – 48 h post): 409 – >564 ppb
  - Mussels (24 – 96 h): 511 – 865 ppb
- Mussels and snails most sensitive genera tested, but 100-173x > target application conc. (3.4 – 5.8x max rate)



Fluridone Comparative Toxicity - Chronic

- Sonar – PR & Genesis typically applied at 5 ppb
  - Max application rate = 150 ppb

- Chronic No Observed Effect Concentration (NOEC)
  - Fathead minnow (7 d): 600 ppm
  - Walleye (8 – 12 d): 780 ppb
  - Mussel (28 d): 300 ppb

Fluridone Comparative Toxicity - Chronic

- Sonar – PR & Genesis typically applied at 5 ppb
  - Max application rate = 150 ppb
- Chronic No Observed Effect Concentration (NOEC)
  - Fathead minnow (7 d): 600 ppm
  - Walleye (8 – 12 d): 780 ppb
  - Mussel (28 d): 300 ppb
- Mussel – highest concentration tested, and 60x > target application conc. (2x max rate)

Endothall Comparative Toxicity - Acute

- Aquathol-K typically applied at 1 – 5 ppm

Endothall Comparative Toxicity - Acute

- Aquathol-K typically applied at 1 – 5 ppm
  - LC50s for freshwater species
    - Daphnia (48h EC50): 223 ppm
    - Fish (96h EC50): > 100 – 1071 ppm
    - Mussels (24 – 96 h): 31 – 34 ppm
    - Snail (96 h): 224 ppm

Endothall Comparative Toxicity - Acute

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    - Daphnia (48h EC50): 223 ppm
    - Fish (96h EC50): > 100 – 1071 ppm
    - Snail (96 h): 224 ppm
    - Mussels (24 – 96 h): 31 – 34 ppm
- Mussels most sensitive species tested, but 6 – 34x > target application concentration

May Treat Hydrilla with Minimal Risk

- Sonar and Aquathol-K appear ***acutely*** non-toxic at typical application rates
- LC50s: 6 – 173-fold greater than recommended applications
  - 2 – 5.8 times max label rates

Scientific Products

Journal of Freshwater Ecology, 2015
Vol. 30, No. 3, 335–348, http://dx.doi.org/10.1080/02705060.2014.945104

Taylor & Francis
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Sensitivity of freshwater molluscs to hydrilla-targeting herbicides: providing context for invasive aquatic weed control in diverse ecosystems

Jennifer M. Archambault[a]*, Christine M. Bergeron[a], W. Gregory Cope[a], Robert J. Richardson[b], Mark A. Heilman[c], J. Edward Corey III[d], Michael D. Netherland[e] and Ryan J. Heise[f]

Freshwater Mollusk Biology and Conservation 19:69–79, 2016

REGULAR ARTICLE

LIFE STAGE SENSITIVITY OF A FRESHWATER SNAIL TO HERBICIDES USED IN INVASIVE AQUATIC WEED CONTROL

Jennifer M. Archambault[1*] and W. Gregory Cope[1]

[1] *Department of Applied Ecology, North Carolina State University, Campus Box 7617, Raleigh, NC 27695 USA*

Making Strides, BUT… Need to Learn Much More

- Sublethal effects
  - Reproductive: transformation success (mussels)
  - Growth – Biomarkers – Behavioral
- Chronic exposures more relevant to lotic systems than acute
- Multi-stressor studies
- Indirect effects (e.g., DO, food availability)